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Hypertension in Pima Indians: Prevalence and Predictors

SYNOPSIS

THE PIMA INDIANS HAVE THE WORLD'S HIGHEST reported incidence of diabetes. Since 1965, this population has participated in a longitudinal epidemiological study of diabetes and its complications. The examinations have included a medical history for diabetes and other major health problems. The focus of this study is the correlation between the prevalence of hypertension and glucose tolerance in this population.

Of the 4315 adults ages 18 and older, 50% had normal glucose tolerance; 12%, impaired glucose tolerance (IGT); 8%, newly diagnosed diabetes; and 31%, previously diagnosed diabetes of a mean duration of 11 years. Age-sex adjusted prevalence of hypertension was 24% in those with normal glucose tolerance, 34% in those with IGT, and 40% in those with diabetes. Hypertension was more common in men than in women and was positively related to obesity. Of the 2667 children ages 6 to 17 years, 4% had IGT, and 1% had diabetes. Blood pressure was higher in boys than girls and was associated with older age and worse glucose tolerance.

Longitudinal analyses of data from 188 children ages 5 to 9 years who had their follow-up exam at ages 18 to 24 revealed no relationship between insulin concentration and blood pressure in either sex. In this group mean blood pressure at followup was positively correlated with relative weight, mean blood pressure, and 2-hour post-load plasma glucose concentration at baseline. In a multiple regression model, relative weight was the strongest predictor of mean blood pressure at the follow-up exam.

The Pima Indians have the world's highest reported incidence of diabetes (1). They develop only non-insulin-dependent diabetes mellitus (NIDDM), which often occurs at younger ages than in other populations (1,2). Nearly one-half of Pima Indians ages 35 to 44 and more than two-thirds age 45 and older have diabetes, and many cases develop before the age of 25. Hypertension is a common complication of NIDDM in this population and has been associated with retinopathy (3) and nephropathy (4).

Methods

Since 1965, this population has participated in a longitudinal epidemiological study of diabetes and its complications (2). Every 2 years community members age 5 years and older take part in examinations that include an oral

Table 1. Study characteristics and prevalence rates of hypertension in adult Pima Indians according to glucose tolerance status

	Glucose Tolerance		Diabetes	
	Normal	Impaired	Newly Diagnosed	Previously Diagnosed
n	2151	499	326	1339
(M/F)	(991/1160)	(188/311)	(139/187)	(512/827)
Mean Age (yrs)	31.3	38.0	39.3	49.3
Mean BMI (kg/m ²)	32.4	35.6	36.7	32.2
Prevalence (%)* of				
Normal BP	63.5	50.3	43.8	48.2
Borderline BP	12.9	15.6	13.2	12.2
Hypertension	23.6	34.1	43.0	39.6

* Age-sex adjusted to the U.S. 1980 census population ages ≥ 18 years. Normal: BP < 130/85. Borderline: systolic or diastolic BP between normal and hypertension. Hypertension: systolic BP ≥ 140 mmHg, diastolic BP ≥ 90 mmHg, or treatment with antihypertensive drugs.

glucose tolerance test, a physical examination, and a medical history relating to diabetes and other major health problems, including hypertension and current drug treatment. Participants comprise those who are at least 50% Pima, Tohono O'odham (Papago), or a mixture of these closely related tribes and had taken part in the study from July 1972 through February 1994, sometimes undergoing examination more than once. This analysis, however, includes only the data from the last examination for adults age 18 and older at the time and data from the first examination for children younger than 18 years.

Blood pressure measurement protocols for this analysis included use of a mercury sphygmomanometer with a large adult cuff (for the purpose of consistency) on the right arm near the end of the examination with the participant resting in the supine position. Trained observers recorded systolic and diastolic blood pressures to the nearest 2 mmHg at the first and fourth Korotkoff sounds, using criteria from *The Fifth Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure* (5) (systolic blood pressure (SBP) ≥ 140 mmHg, diastolic blood pressure (DBP) ≥ 90 mmHg, or treatment with antihypertensive drugs) to define hypertension. Blood pressure < 130 (systolic) and < 85 (diastolic) was *normal*. Systolic or diastolic blood pressure higher than normal but lower than the criteria set for hypertension

Table 2. Mean systolic and diastolic blood pressure in Pima Indian children between ages 6 and 17 years

Age	Sex	Glucose Tolerance		
		Normal	Impaired	Diabetes
6-9	M	95/53 (n=419)	119/53 (n=3)	
	F	93/53 (n=426)	108/62 (n=11)	
10-12	M	105/58 (n=406)	114/60 (n=17)	108/44 (n=3)
	F	104/58 (n=386)	107/59 (n=28)	111/65 (n=4)
13-15	M	115/63 (n=299)	121/64 (n=17)	143/71 (n=3)
	F	109/63 (n=266)	117/64 (n=19)	117/67 (n=8)
16-17	M	119/67 (n=135)	128/73 (n=12)	133/80 (n=4)
	F	110/64 (n=183)	115/66 (n=13)	112/67 (n=5)

was *borderline*. Two-thirds the diastolic blood pressure plus one-third the systolic blood pressure constituted the mean blood pressure.

Glucose tolerance was classified according to World Health Organization (WHO) criteria (6) using venous plasma samples obtained fasting and 2 hours after a 75-gram glucose-equivalent carbohydrate load, as follows: fasting plasma glucose < 7.8 mM and 2-hour post-load plasma glucose ≥ 7.8 and < 11.1 mM was *impaired glucose tolerance* (IGT), fasting plasma glucose ≥ 7.8 mM or 2-hour post-load plasma glucose ≥ 11.1 mM was *diabetes mellitus*, and diabetes diagnosed fewer than 2 months before the research examination was *newly diagnosed*.

The formula used to calculate body mass index (BMI), a measure of obesity, was weight in kilograms divided by the square of height in meters. Because BMI is strongly correlated with height in growing children, relative weight, expressed as a percent, was calculated from the child's weight and an age-sex-specific standard weight for height (7).

Results

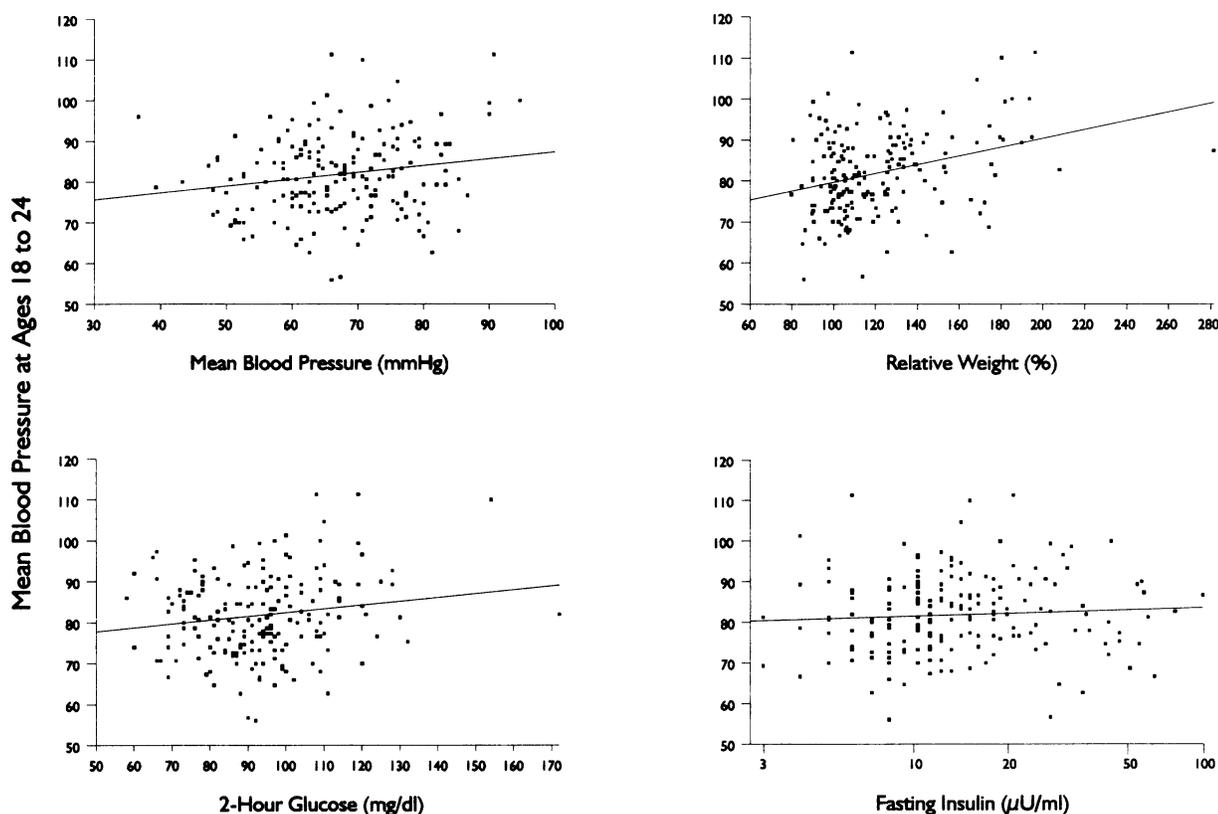
Table 1 shows the characteristics of 4315 adults included in the study: 50% had normal glucose tolerance, 12% had IGT, 8% had newly diagnosed diabetes, and 31% had diabetes of 2 months' to 38 years' duration (mean of 11 years). Hypertension was present in 26% of the participants and was more common in men (35%) than in women (20%). The age-sex-adjusted (to the U.S. 1980 census) prevalence of hypertension was 24% in participants with normal glucose tolerance, 34% in those with IGT, and 40% in those with diabetes. The age-sex-adjusted prevalence of hypertension by glucose tolerance status in relation to obesity showed a strong association between hypertension and abnormal glucose tolerance regardless of age, sex, or obesity with higher rates in the more obese participants in all strata.

Of the 2667 children 95% had normal glucose tolerance, 4% had IGT, and 1% had diabetes (mean duration of 2 years). Blood pressure in children between ages 6 and 17 years was higher in boys than in girls and was associated with older age and worse glucose tolerance (Table 2).

Predictors of blood pressure were assessed in data from 188 children (67 boys, 121 girls) with complete examinations, including assessment of fasting and 2-hour post-load insulin concentrations, who had their first examination at ages 5 to 9 years and a follow-up examination at ages 18 to 24. At baseline, none had hypertension, but 2 had IGT. At followup (mean of 12.3 years after baseline), 9 (8 males, 1 female) had hypertension, 19 had IGT, and 15 had diabetes; two additional participants taking antihypertensive drugs at the second exam were excluded from the analysis.

Mean blood pressure at ages 18 to 24 correlated positively with the following variables measured at baseline:

Figure 1. Correlation of mean blood pressure measured at ages 18 to 24 years with baseline variables measured at ages 5 to 9 years in Pima Indians. Correlations: mean blood pressure (R=0.17, P=0.014), relative weight (R=0.32, P<0.0001), 2-hour post-load plasma glucose concentration (R=0.16, P=0.028), and fasting serum insulin concentrations (R=0.06, P=0.38)



relative weight (R=0.32, P <0.0001), mean blood pressure (R=0.17, P=0.014), and 2-hour post-load plasma glucose concentration (R=0.16, P=0.028), but not with serum insulin concentrations (Figure 1). In a multiple regression model with baseline mean blood pressure, relative weight, fasting and 2-hour post-load values for glucose and insulin, and age, only relative weight significantly predicted (P <0.05) mean blood pressure at the follow-up exam in each sex. In logistic regression analysis in males none of the variables predicted hypertension at the second examination. This analysis was not performed in women, since there was only one incident case of hypertension in this group.

Discussion

Blood pressure (or hypertension) is related to glucose tolerance in the Pima population. In a previous study of non-diabetic Pima Indians ages 25 to 74, the age-sex-adjusted prevalence of hypertension according to the WHO criteria (SBP ≥ 160 mmHg, DBP ≥ 95 mmHg, or treatment with antihypertensive drugs) was 14% com-

pared with 22% for the corresponding U.S. population (8).

Several researchers have examined the relationships of blood pressure with glucose tolerance and obesity in adults and children in many populations. Some of them point to hyperinsulinemia as the basis for this relationship, since serum insulin concentrations tend to be higher in persons with IGT and in some persons with diabetes than in those with normal glucose tolerance; however, many drugs used in treating high blood pressure may also affect insulin resistance or glycemia. Thus, examination of these variables is difficult if studies include people taking antihypertensive drugs. The present study examined the relationship between insulin and blood pressure in 188 Pima children. The longitudinal analyses of this group revealed no relationship between insulin concentration and blood pressure in either sex.

In conclusion, blood pressure and hypertension are significantly related to plasma glucose concentration and BMI or relative weight. However, in Pima Indians, insulin seems not to be a major link between hypertension and obesity or glucose intolerance.

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